



# Making IT Rain with Cloud Computing

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IT Chief Technology Officer

and

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Missions Cloud Expert

Jet Propulsion Laboratory, California Institute of Technology.

*“One must learn by doing the thing;  
for though you think you know it, you have no certainty until you try.” - Sophocles*

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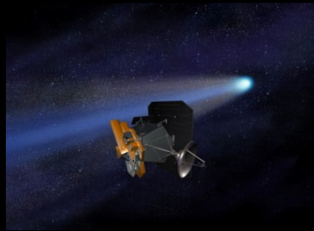
- JPL is a Federally Funded Research and Development Center (FFRDC) Managed by CalTech for NASA
- NASA's lead center for robotic exploration of the solar system. Have 19 spacecraft and 9 instruments across the solar system and beyond
- \$1.7B contract per year, ~ 5,000 employees; 177 acre facility located in Pasadena, CA, with 670K sq.ft of office space and 900K sq.ft. of labs



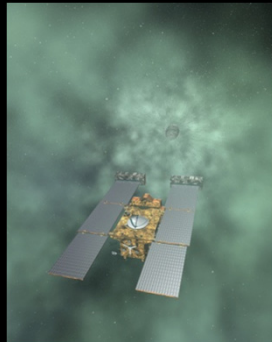
- Manages worldwide Deep Space Network
  - 3 Locations - Goldstone CA, Madrid Spain, Canberra Australia
  - Spacecraft Command & Control - Recording scientific data
- 50+ years experience in spacecraft design, production, operation
- JPL spacecraft have visited all planets in our solar system except Pluto!



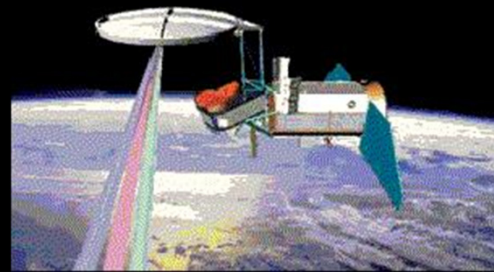
# Upcoming Mars & Solar System Exploration Events



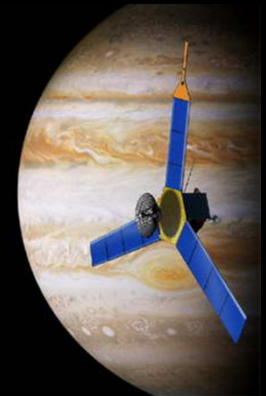
EPOXI  
Comet  
Flyby



Stardust-  
NEXT  
Comet  
Flyby



Aquarius  
April 2011



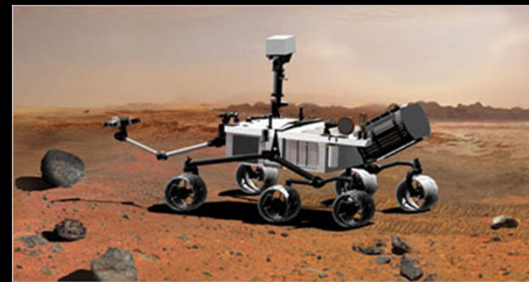
Juno  
August  
2011



Dawn Vesta  
Arrival  
August 2011  
(Ceres, February



GRAIL  
September  
2011



Mars Science  
Laboratory  
November 2011

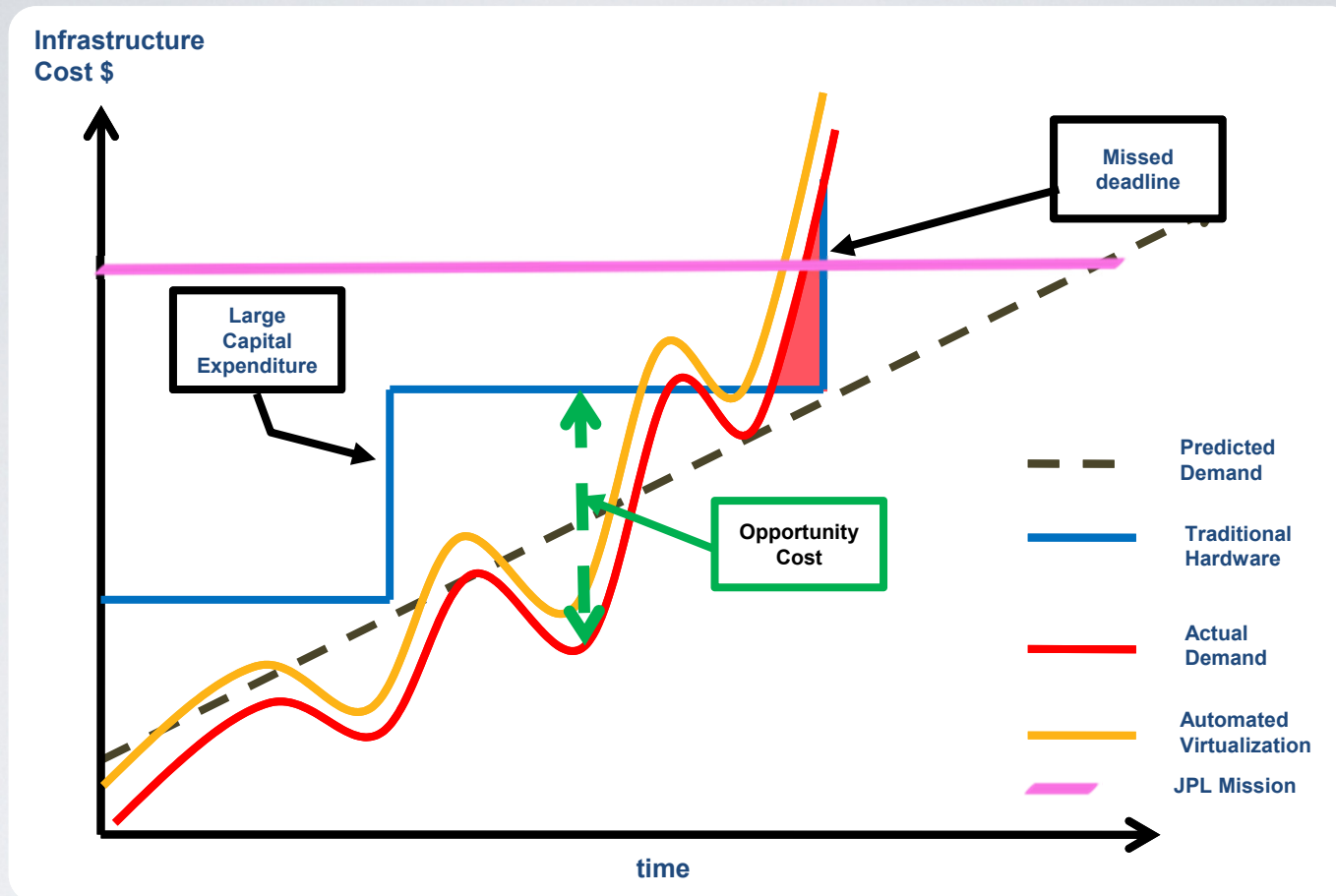


NuSTAR  
January  
2012

# PEARL STREET STATION







# Mission Operations Computers



JPL

OCIO

Enterprise Information Technology





Joseph C (1731-Affiliate)	RE: New Maestro Blade	August 6, 2009
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Ronald V (172H)	RE: New Maestro Blade	August 6, 2009
Tong (1731-Affiliate)	RE: New Maestro Blade	August 5, 2009
Shams	Re: New Maestro Blade	August 5, 2009
Shams	FW: New Maestro Blade	August 5, 2009
Joseph C (1731-Affiliate)	RE: New Maestro Blade	August 5, 2009
Shams	Re: New Maestro Blade	August 5, 2009
Bryan (315H)	Re: New Maestro Blade	August 5, 2009
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Jeff	Re: New Maestro Blade	August 5, 2009
Bryan (315H)	Re: New Maestro Blade	August 5, 2009
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Douglas S (1733)	Out of Office: New Maestro Blade	August 5, 2009
Joseph C (1731-Affiliate)	RE: New Maestro Blade	August 4, 2009
Margaret K (1731-Affiliate)	RE: New Maestro Blade	August 4, 2009
Joseph C (1731-Affiliate)	RE: New Maestro Blade	August 4, 2009
Joseph C (1731-Affiliate)	RE: New Maestro Blade	August 2, 2009
Shams	Re: New Maestro Blade	July 31, 2009
Shams	FW: New Maestro Blade	July 31, 2009
er, Cris D (172H)	RE: New Maestro Blade	July 31, 2009
Joseph C (1731-Affiliate)	RE: New Maestro Blade	July 29, 2009
Joseph C (1731-Affiliate)	RE: New Maestro Blade	July 29, 2009
Bryan (315H)	Re: New Maestro Blade	July 28, 2009
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Joseph C (1731-Affiliate)	RE: New Maestro Blade	July 28, 2009
Shams	Re: New Maestro Blade	July 28, 2009
Jaime C (172H)	Out of Office: New Maestro Blade	July 28, 2009
Douglas S (1733)	Re: New Maestro Blade	July 28, 2009
(173G)	RE: New Maestro Blade	July 28, 2009
Douglas S (1733)	Re: New Maestro Blade	July 28, 2009
Jeff Norris	Re: Confirming configuration of new MAESTRO...	July 28, 2009

[REDACTED] s, Ronald V (172H)  
 [REDACTED] s, Joseph C (1731-Affiliate)  
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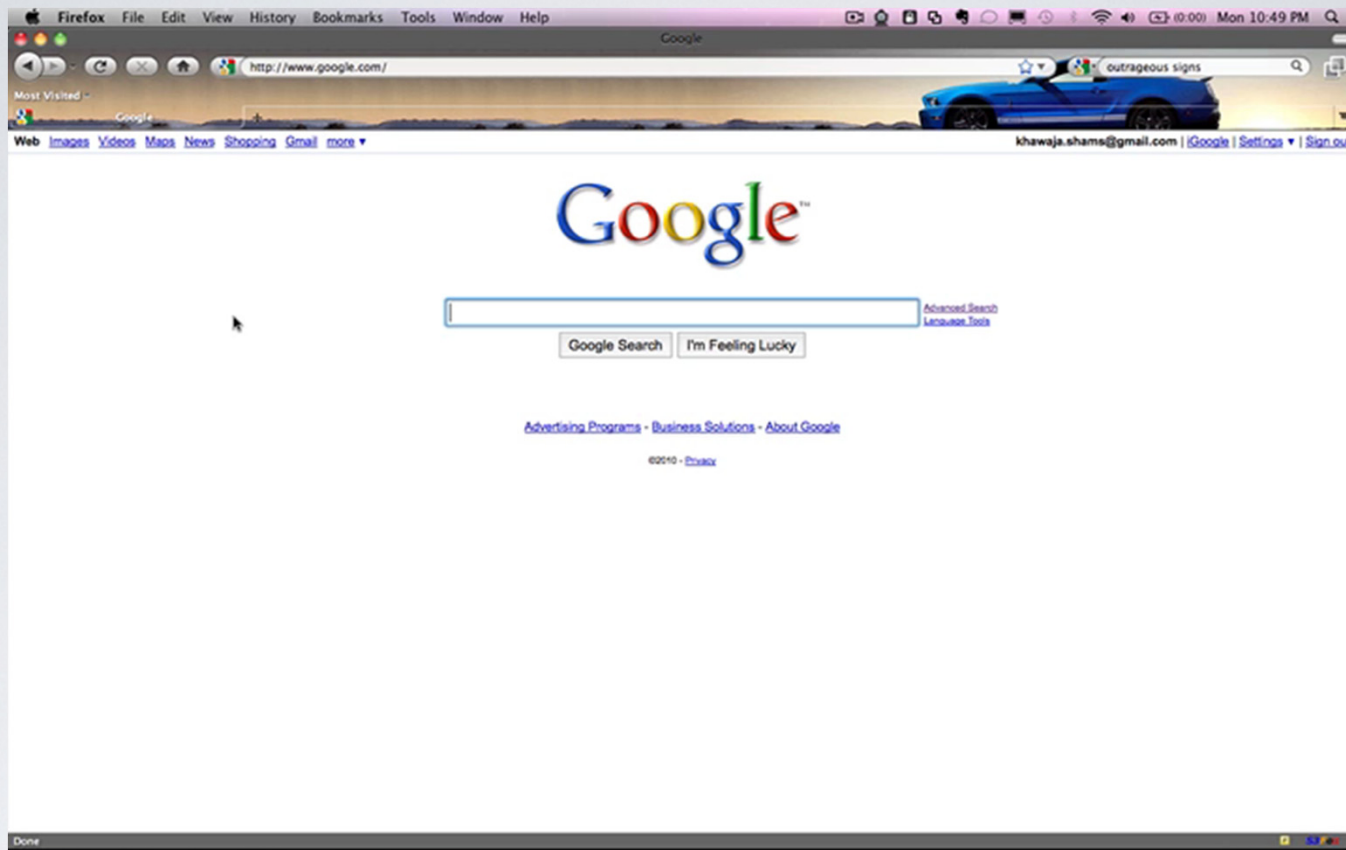


Replace Every Procurement Screen with a Provisioning Screen.  
Jim Rinaldi - CIO JPL



# What Compute Capacity means to JPLers





Here comes the rain...

# JPL's approach to Cloud Computing

But how?



- **Focus on real business problems**
- Early hands-on prototypes of enabling capabilities in every promising cloud
- Avoid analysis paralysis, but be safe
- Educate, communicate, influence, elaborate
- **Keep it real**
- Pro-active partnering



# Let's Move to the Cloud!



# Contract Negotiations!



# First to Sign!





# Fostering the IT Consumers' Ingenuity



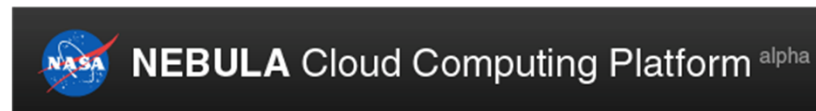
## INGENUITY

Because One Just Isn't Enough

lol MotivatedPhotos.com

IT → “Innovating Together”

# JPL Partners



Google

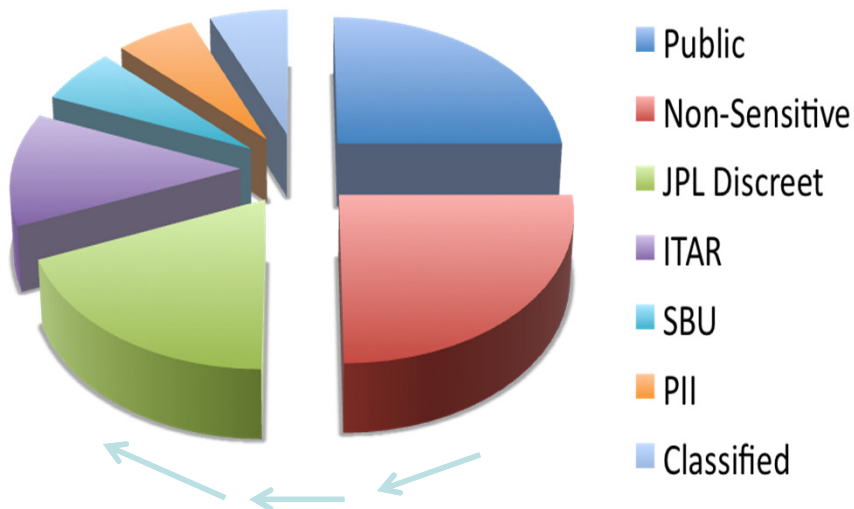


Microsoft

# Cloud Computing Concepts

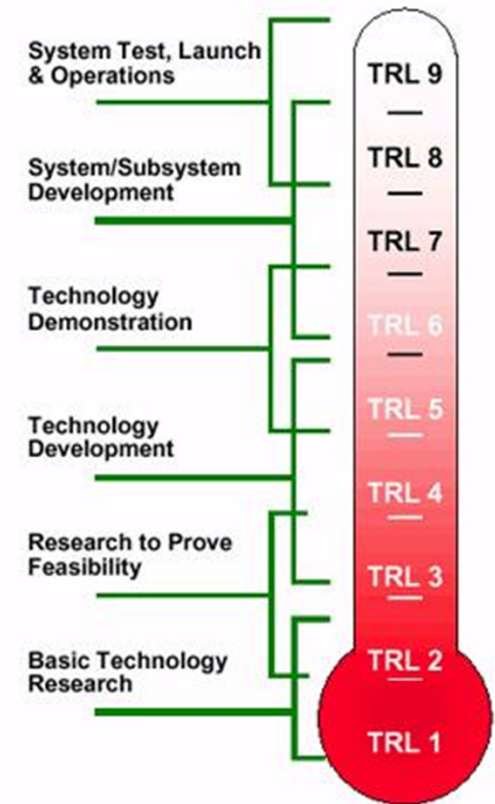
## 1. Cloud Application Suitability Model (CASM)

## 2. Wheel of Security



Public and Non-Sensitive data can be accessed  
in the Cloud today

## 3. Cloud Readiness Levels (CRL) (Institution, Apps, Dev)



NASA Technology Readiness Level

[http://en.wikipedia.org/wiki/File:NASA\\_TRL\\_Meter.jpg](http://en.wikipedia.org/wiki/File:NASA_TRL_Meter.jpg)

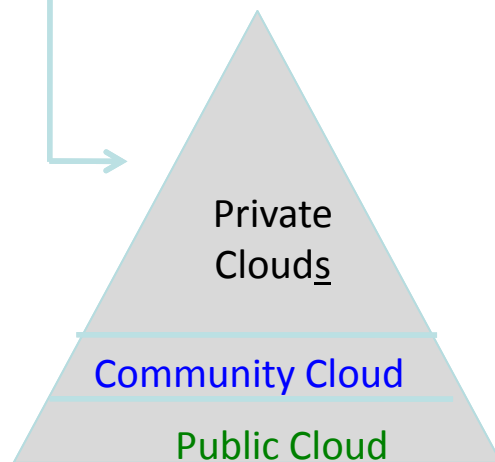
## 4. Cloud Oriented Architecture (CIOA)



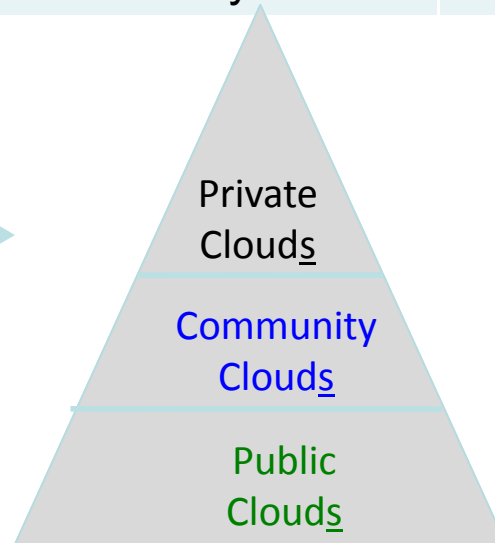
# Cloud App Suitability Model determines application location

**App Req' ts:**  
Security, ITAR,  
app type,  
bandwidth,  
uptime, etc

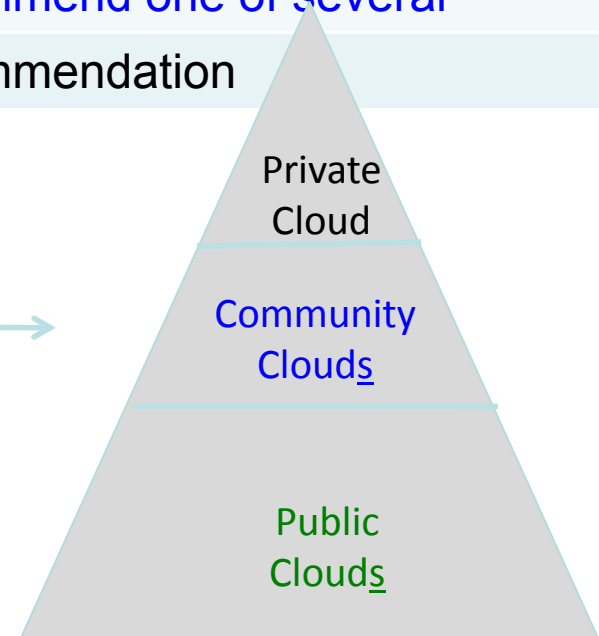
Score	Cloud Type	Testing → Need for a “Cloud Broker”
76-100	Public	Recommends one of several
50-75	Community or Hybrid	Recommend one of several
0-49	Private or Hybrid	Recommendation



**Today**



**Within 2 Years**



**Future**

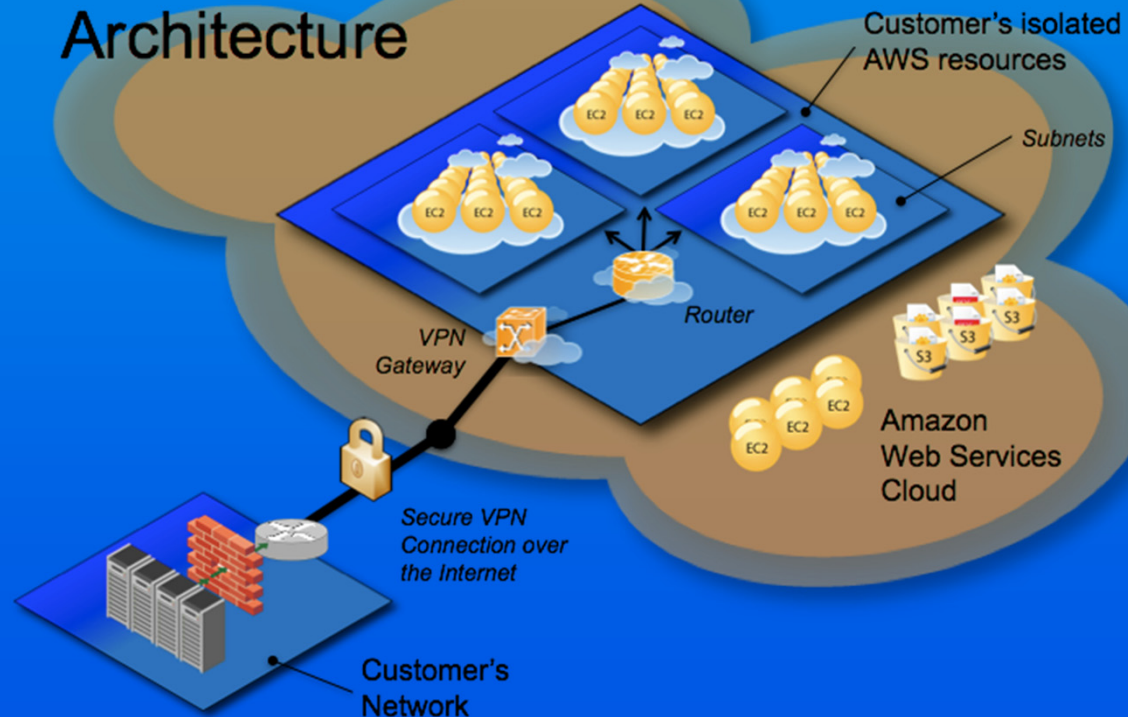
→ *We'll become faster, cheaper, greener, more flexible, and a partner of choice*

Data in  
Cloud



Public Data

## Amazon VPC Architecture



# Virtual Private Cloud



# *JPL Cloud Uses: Outreach for Citizen Scientists*

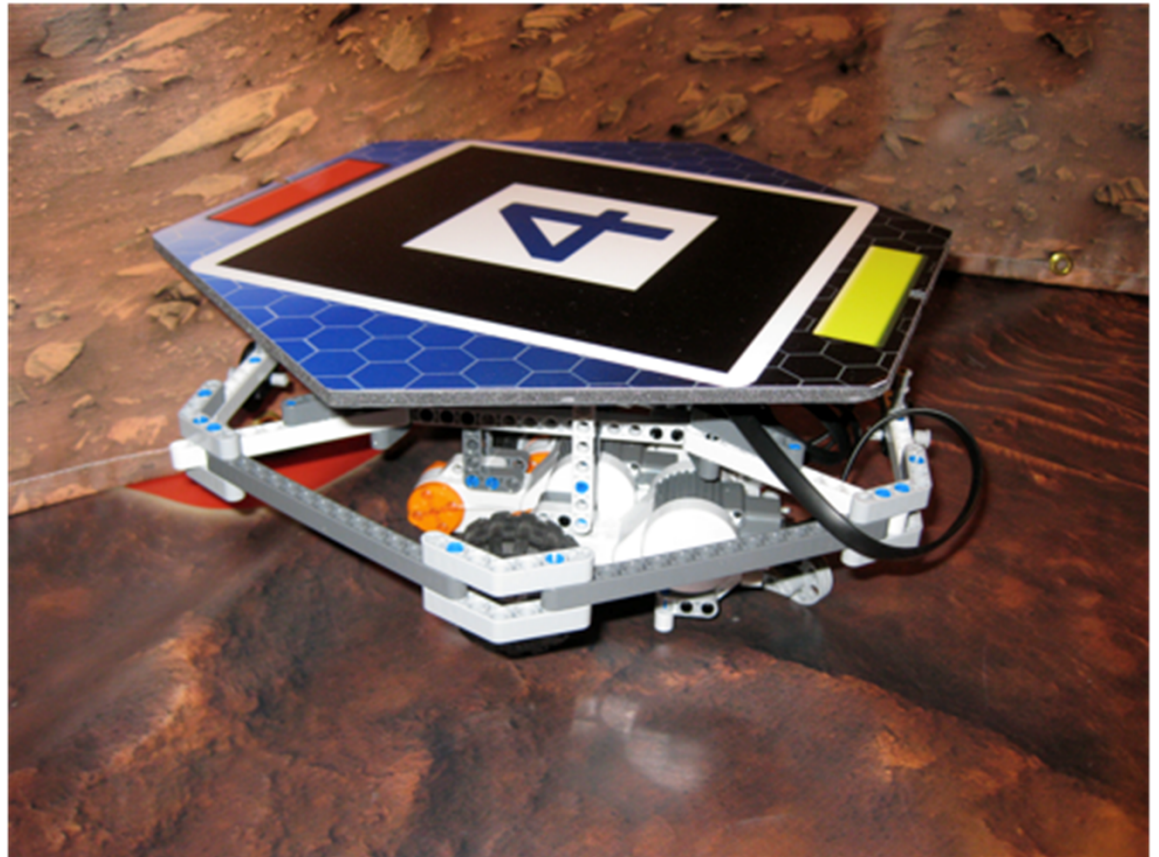
BeaMartian.jpl.nasa.gov

Reaches MS Cloud developers / citizen scientists of all ages



## *JPL Cloud Uses: Crowd Sourcing for E4 Rover*

- At EclipseCon 2010, a competition to drive a “Mars rover”
- Innovative concepts. Great programs. Exciting and fun
- It was all in Amazon’s Cloud (no JPL computing resources)







# Mars-2-Earth



UCSD

**JPL**

Jet Propulsion Laboratory  
California Institute of Technology





# Mars-2-Earth



UCSD

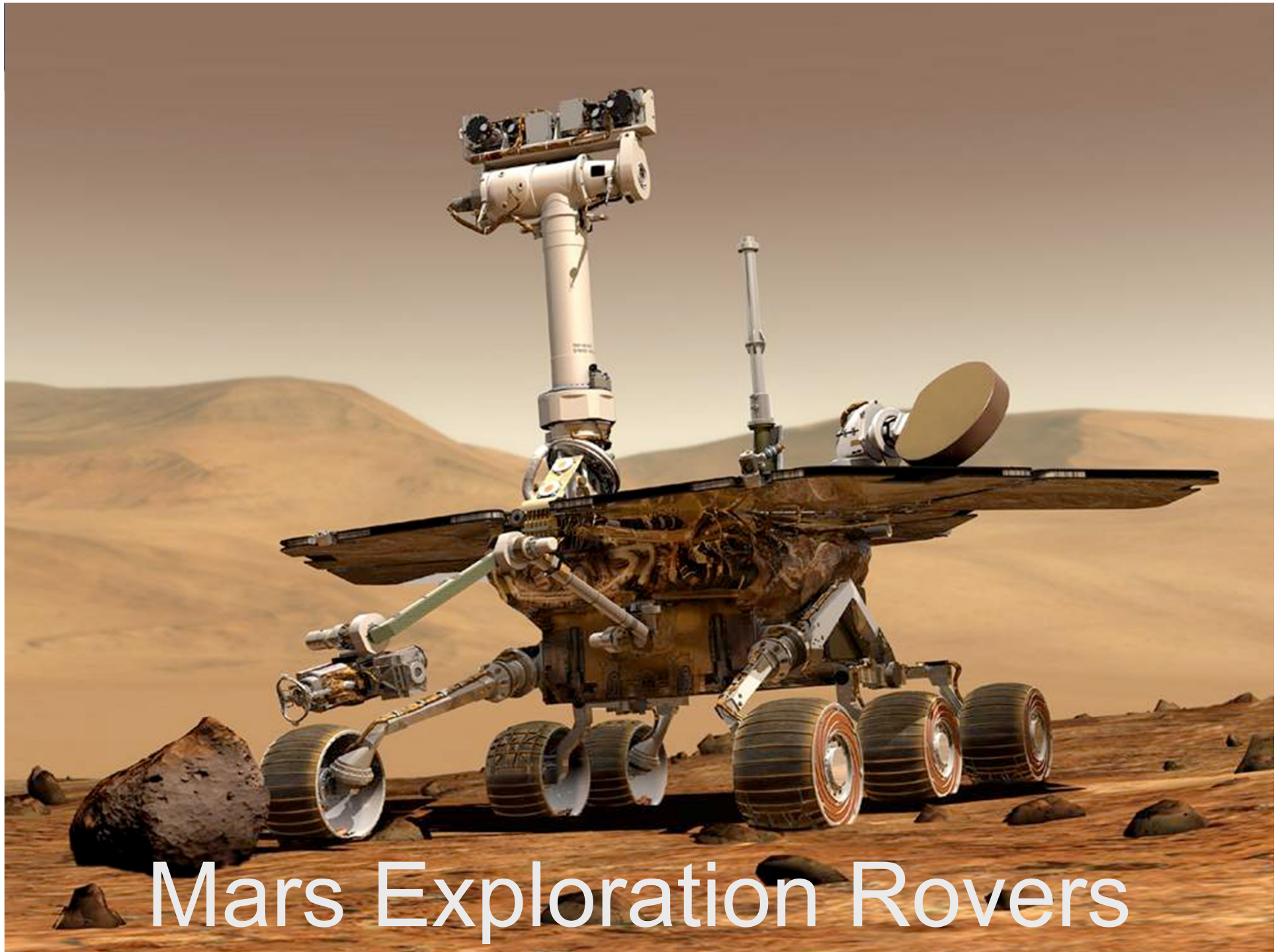
**JPL**

Jet Propulsion Laboratory  
California Institute of Technology



## *JPL Cloud Uses: Amazon HPC usage for Athlete*





Mars Exploration Rovers



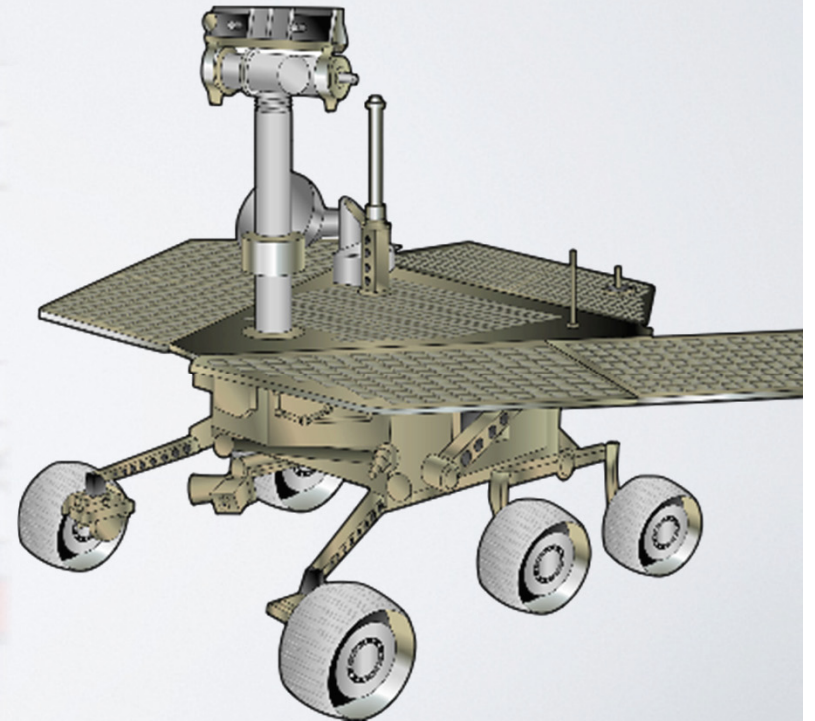
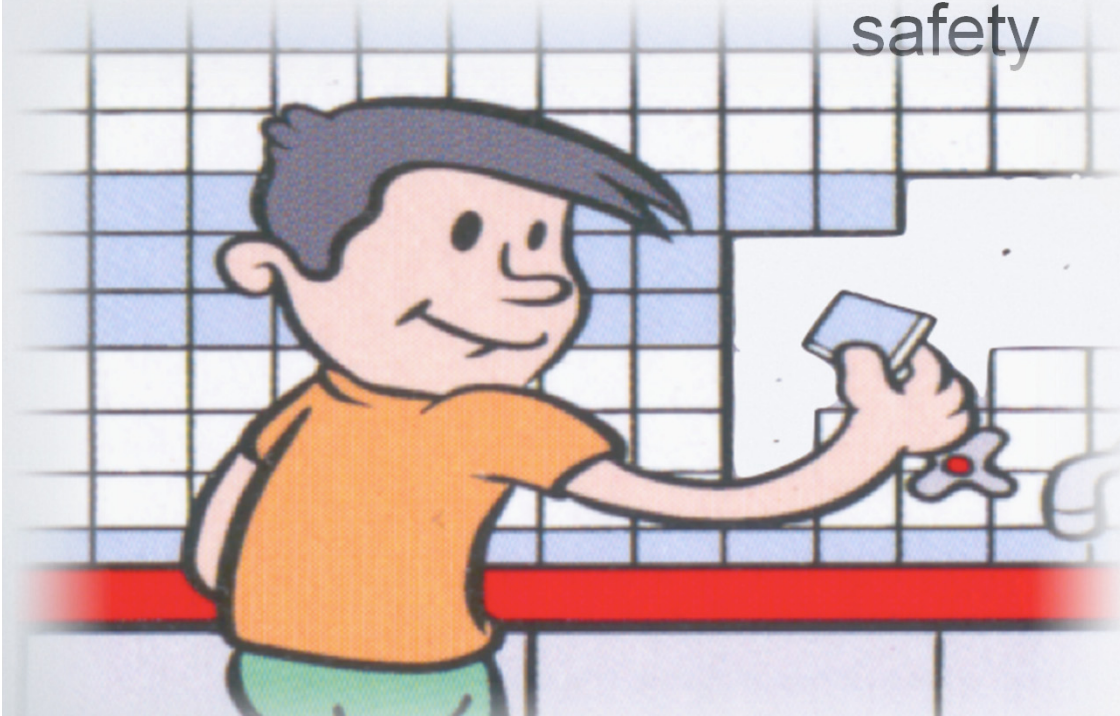
# MER Image Processing

Embarrassingly parallel application

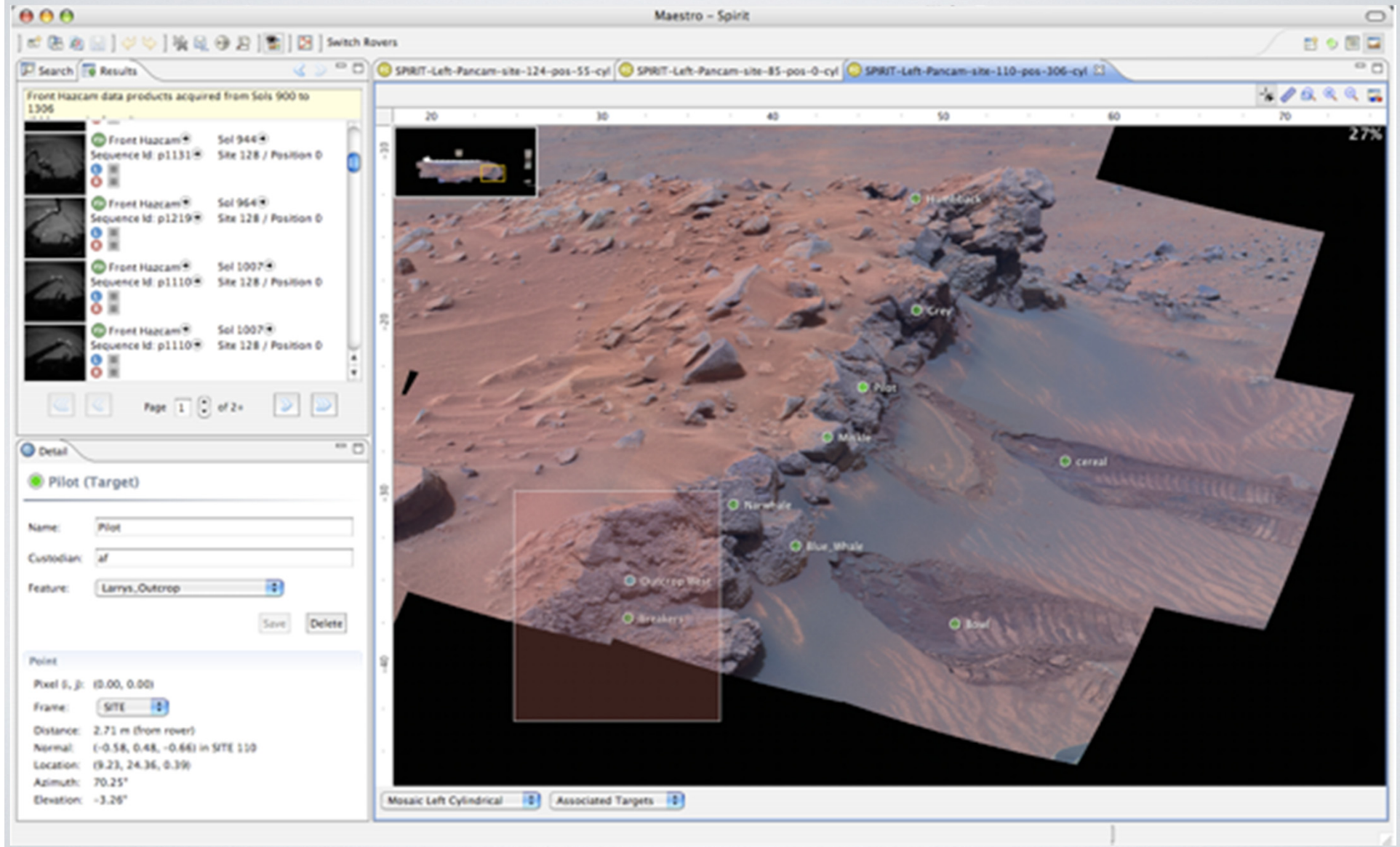
Process and deliver from Cloud

Streamlined image processing through Cloud  
Computing

Better situational awareness, better science, better  
safety



# Maestro for MER





# POLYPHONY

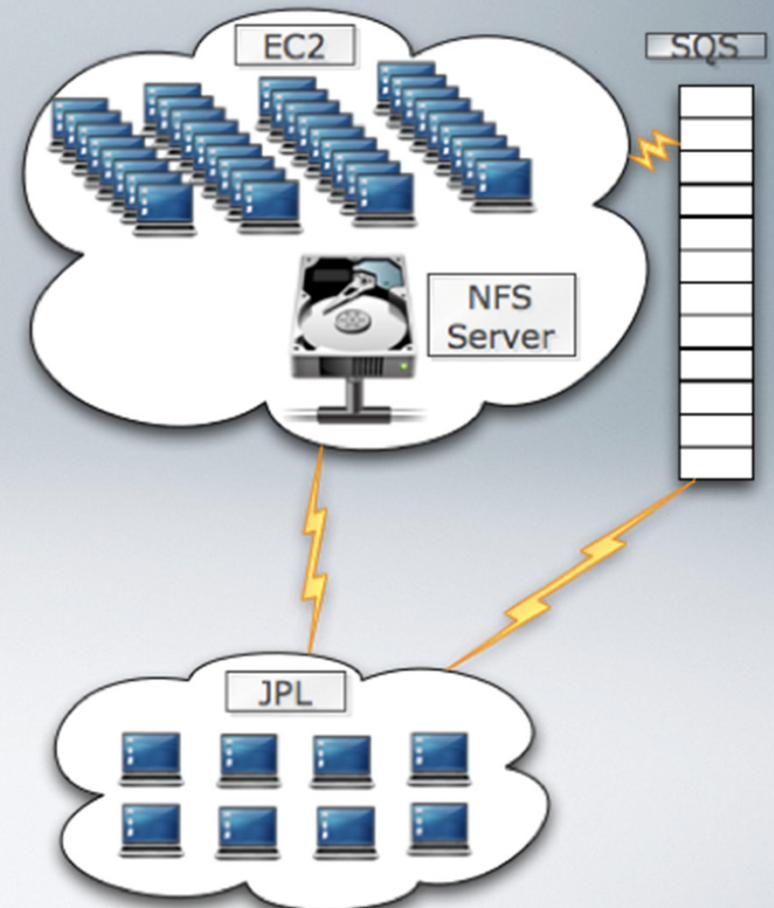
## IMAGE PROCESSING ON CLOUD

~ Quarter Million Images  
Quarter of a \*day\*  
<\$200



Weeks  Days

Polyphony Architectural Diagram





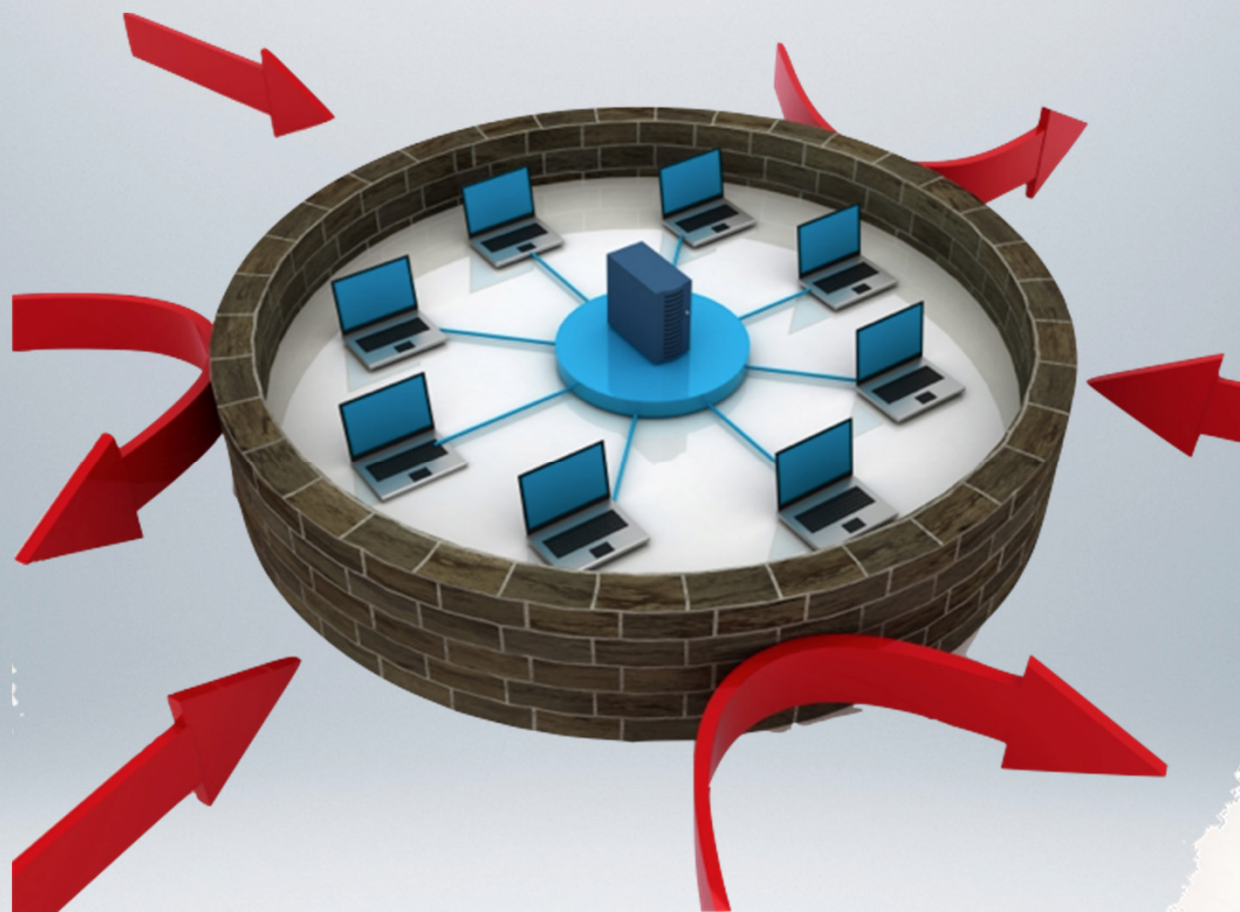
# Physical Control



# Who Do We Already Trust?



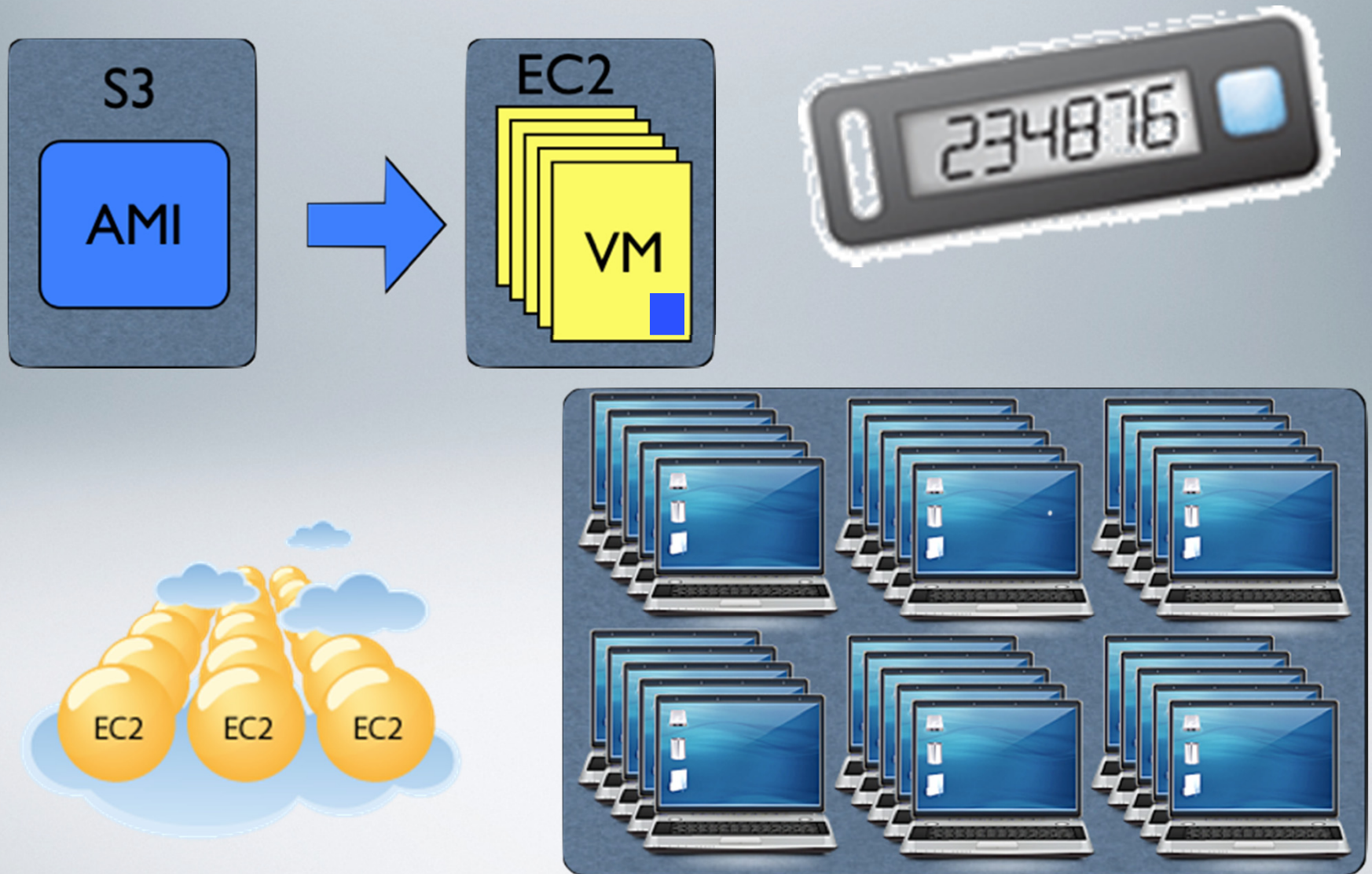




Can Clouds Be Safer?



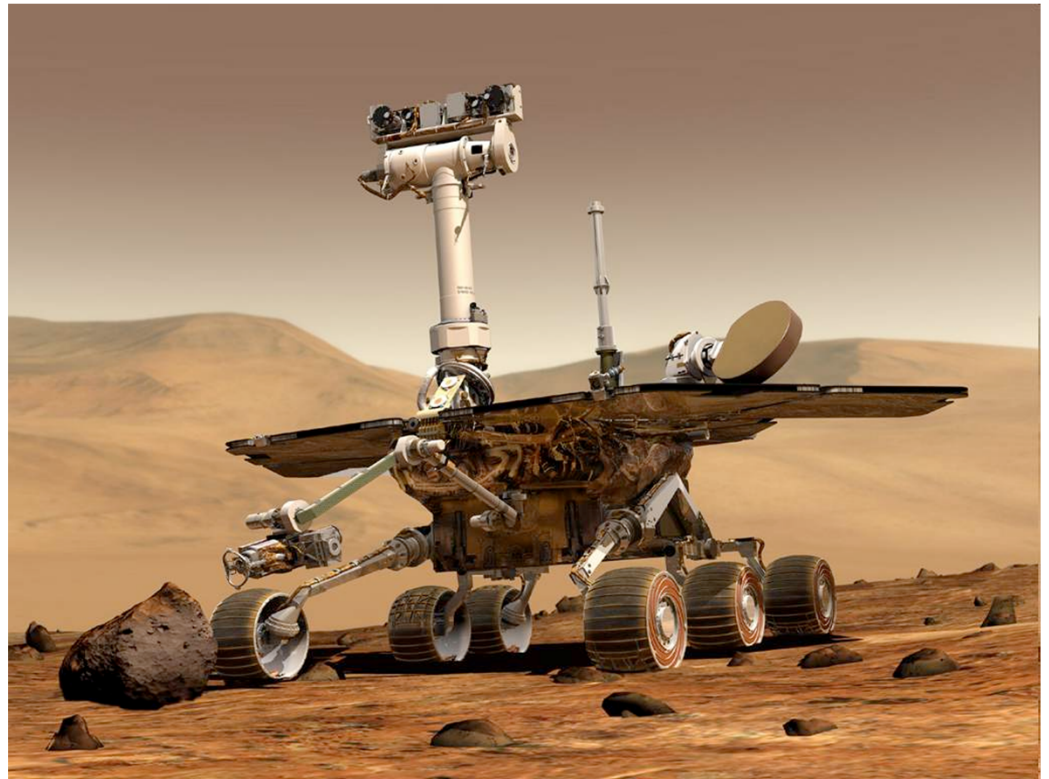
# Security through Uniformity



## *JPL Cloud Uses: Observed Mission Benefits*

### **A few examples of prototyped benefits so far:**

- From weeks to hours to process Saturn images
- 15% more time for scientists world wide on Mars rovers
- From days to hours to model computations (e.g. DSN)
- Can reduce ops costs
- Can reduce risk
- Can speed experiments
- Augments JPL resources
- **Partnering pays off!**





## *JPL Cloud Strategy: What's next*



**→ Cloud is THE enabler... if we continue to Keep it Real**



## *JPL Cloud Strategy: What's next for JPL and Clouds*

- We transition from understanding the Cloud to working in the Cloud to partnering in the Cloud
- The Cloud enables everything ... if we let it (e.g. PC 3.0)
- Specialized Clouds become the Operating System
- JPL will advance the Cloud Readiness Levels (CRL) and Cloud Oriented Architecture (COA)
- Transition Cloud from Pilot to Operational mode
- Spin the Wheel of Security and evaluate more Use Cases
- Automate the Cloud Application Suitability Model (CASM)
- Continue to keep it real and benefit from employees' and partners' ingenious usage of Clouds

**Take full advantage of the Pervasive Cloud**

*Can we live without making IT rain?*





## *What can YOU do about Cloud computing?*

- Get started now with low sensitivity data
- Focus on new capabilities
- Prototype under the radar screen
- Communicate it as a business initiative (ROA)
- Partner with everyone
- Use the 3-floor elevator test
- Create a cross-functional leadership team focused on the concept (legal, procurement, security, facilities, business leaders, IT)
- Expect license agreement to take time
- **Keep it real**

